Claims

1. Apparatus for locating an emitter of electromagnetic waves by means of a plurality of receivers, each receiver including means for detecting the time of arrival of said electromagnetic waves at said receiver, and means for computing the relative time differences of arrival between said receivers and for estimating therefrom the position of the emitter, and including means for correcting said detected times of arrival for path length discrepancies caused by the earth's atmosphere.

2. Apparatus according to claim 1, wherein the discrepancies are caused by refraction.

3. Apparatus according to claim 1 or 2, wherein each said receiver is mounted on a respective airborne platform, and at least three pairs of said receivers are provided.

4. Apparatus according to claim 3, wherein said correcting means is arranged to carry out the following steps:

    a) measure time differences of arrival between pairs of said receivers;

    b) assuming straight-line paths, obtain an estimate of emitter position;

    c) for each receiver: using said estimate, obtain the ground range from emitter to a receiving platform;

    d) using said ground range, and known height, and assumed refractive profile in a selected ray-tracing integral equation to predict actual path length;

    e) obtain the difference between said predicted path length and the straight-line path obtained from the estimated emitter position to form a correction to said time differences of arrival in Step a);

    f) return to Step b);

    g) Continue until the corrections in Step e) converge.

5. Apparatus according to any preceding claim, wherein, said correcting means is arranged to perform the following ray tracing equation

$$.R=\int_{h_0}^{h_1}\frac{n(h)}{\sqrt{1-\left[\dfrac{n_0\cos(\theta_0)}{n(h)\left[1+\dfrac{h}{re}\right]}\right]^2}}.dh\,,$$

where R is the path length, n (h) describes the atmospheric refractive profile as a function of height, n_0 is the refractive index at the earth surface, θ_0 is the take-off angle of the ray at the emitter, h_0 and h_1 are the start and end heights of the path, re is the earth radius.

6. Apparatus according to any preceding claim, including a Kalman filter for improving said correction.

7. A method for locating an emitter of electromagnetic waves by means of a plurality of receivers, comprising detecting the times of arrival of said electromagnetic waves at said receivers, computing the relative time differences of arrival between said receivers and estimating therefrom the position of the emitter, and correcting said detected times of arrival for path length discrepancies caused by the earth's atmosphere.

8. A method according to claim 7, wherein the discrepancies are caused by refraction.

9. A method according to claim 7 or 8, wherein said receivers are each mounted on a respective airborne platform, and at least three pairs of said receivers are provided.

10. A method according to claim 9, wherein said correcting is carried out by the following steps:

a) measure time differences of arrival between pairs of said receivers;

b) assuming straight-line paths, obtain an estimate of emitter position;

c) for each receiver: using said estimate, obtain the ground range from emitter to a receiving platform;

d) using said ground range, and known height, and assumed refractive profile in a selected ray-tracing integral equation to predict actual path length;

e) obtain the difference between said predicted path length and the straight-line path obtained from the estimated emitter position to form a correction to said time differences of arrival in Step a)

f) return to Step b)

g) continue until the corrections in Step e) converge.

11. A method according to any of claims 7 to 10, wherein said correcting performs the following ray tracing equation

$$R=\int_{h_0}^{h_1}\frac{n(h)}{\sqrt{1-\left[\frac{n_0\cos(\theta_0)}{n(h)\left[1+\frac{h}{re}\right]}\right]^2}}.dh\ ,$$

where R is the path length, n (h) describes the atmospheric refractive profile as a function of height, n_0 is the refractive index at the earth surface, θ_0 is the take-off angle of the ray at the emitter, h_0 and h_1 are the start and end heights of the path, re is the earth radius.

12. A method according to any of claims 7 to 11, including providing a Kalman filter for improving said correction.

13. A computer program comprising program code means for performing the method steps of any of claims 7 to 12 when the program is run on a computer.

14. A computer program product comprising program code means stored on a computer readable medium for performing the method steps of any of claims 7 to 12 when the program is run on a computer.

15. A computer program which when loaded into a computer will enable it to operate in the apparatus of any of claims 1 to 6.

16. An apparatus substantially as hereinbefore described with reference to any of the accompanying figures.

17. A method substantially as hereinbefore described with reference to any of the accompanying Figures.